GENETICALLY ENGINEERED (GE) ORGANISMS

HEALTH IMPLICATIONS
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Background: The introduction of genetically modified organisms (GMO) into American food production has sparked debate among growers, industry, government, activists and consumers. Major reasons to develop GE crops are to ward off pests, kill weeds, resist diseases or adverse growing conditions, and for pharmaceutical production (3). Since 1987 more than 10,000 GE organisms have been field-tested and more than 60 have been deregulated (approved for commercial production) (9,12). Estimates are that 70% of foods in US retail markets contain some quantity of crops that have been genetically engineered. But which, and how much, are unknown since labeling in the US is not required (2). Twelve different genetically engineered plants have been approved for commercial production in the US; many have multiple patented varieties, although some were never or only locally marketed, or available only briefly. More than 50 GE food products have been evaluated by the FDA and found to be as safe as conventional foods (12). GE is also widely used to produce human and animal hormones, and related treatments (16).

Under the FDA, the Animal and Plant Health Inspection Service (APHIS) regulates health aspects of GMOs, including those grown for pharmaceutical intent. USDA regulates development of transgenic crops (transgenesis is the introduction of a gene or genes into plant or animal cells, which leads to the transmission of the input gene (transgene) to successive generations). The EPA has the responsibility to determine that pesticides introduced into plants are safe for human and animal consumption, and the environment. For GE foods, the FDA has published safety testing guidelines, established consultation processes with industry, and uses independent outside scientific expertise (12). Some concerned citizens and scientists urge that consultation be made mandatory, but it remains voluntary at present. The FDA also evaluates GE foods from outside the US, and marketed here. In 2003 the Codex Alimentarius Commission, established by the WHO, and the Food and Agriculture Organization of the U.N., adopted guidelines for biotech food consumer safety; these are consistent with those of the FDA. Codex is the highest international body on food standards.

Reports by the National Academy of Sciences in 2000, and by the GAO in 2002, were "not aware of any evidence that foods on the market are unsafe to eat as the result of genetic modification" (12). In 2003 the international Organization for Economic Cooperation and Development published a consensus document noting that "there is no evidence to date from animal feeding studies with bioengineered plants that the performance of animals differed in any respect from those fed the non-bioengineered counterpart (12).

100 million acres of GE crops were planted in the U.S. in 2003. A major concern has been risking valuable international markets, which generally oppose GMOs. There are no GE animals approved for human consumption, but several GE bacteria and fungi are commonly used in food production (2). Major crops include soybeans (81% total), canola (60%), corn (40%), cotton (71%). The reduced use of pesticides and fertilizer has lowered costs, improved

yields, and in less developed countries such as China greatly reduced pesticide-related illnesses and deaths (1). In countries where malnutrition and starvation cause death, planting GE crops may have positive or negative health and/or economic implications. For example, conglomeratization may push out small food producers, whose loss of livelihood may have negative health impacts. Thus, opinions of health-related risk-benefit ratios vary by consumer, producer, scientist, and nation.

Breeding Techniques: There are four types of breeding: 1) Natural selection (no intervention). 2) Classical cross-breeding (hybridization), with plant/animal selection over generations, for the characteristics/traits desired. 3) Smart breeding, which identifies dormant traits from heirloom varieties of the same species, and then uses natural breeding methods, not genetic engineering, to move these desired traits into the target plant, and 4) Genetic engineering: This is usually defined as the placement of genetic material from one species into another, and may be accomplish by many different techniques, including transportation by various viruses or bacteria, physical insertion, gene splicing, or chemical manipulation.

"Smart breeding" works by selecting, dye tagging and then using natural methods to re-achieve durability, drought resistance, better nutritional value, etc. previously 'lost' by natural selection or cross-breeding. Less controversial, more predictable and largely unpatentable, the key is precise knowledge and speed of identification of the role each gene plays in a plant's makeup, via biotechnology. This science-based approach is rapidly expanding (15). The evolution of these so-called "superorganics" may please the consumer, the producer, the activist, and the FDA (1).

Consumers and Labeling: Many large, non-organic, producers embrace GMO crops, but consumers have a harder time understanding the benefits, while environmentalists and others criticize GMOs as "unnatural creations" which may harm our bodies (1), or create "insidious biologic pollution" (4). Consumer advocates and organizations such as the Union of Concerned Scientists urge the FDA to require labeling to identify which foods are GE. "Multiple consumer survey studies of GE food attitudes show limited opposition to biotech products, and yet consumer acceptance is still cited as a barrier to adoption or development of biotechnology" (5,10). Congress provides limited basis upon which to require food labeling; generally there must be something tangibly different about the food, not how it is made (3). From a health perspective, labeling is only useful if there is a known deleterious health effect of a specific GE food. Any significant differences between a GE food and its conventional counterpart currently have to be disclosed in labeling, including nutritional properties, presence of an allergen, and properties leading to different cooking, storage, handling or preservation requirements (3).

Health Issues: The British Medical Association (BMA) has issued several interim statements about "the lack of robust and thorough search into the potentially harmful effects of GE foodstuffs on human health"(6). These appear to be internal working documents, or are directed to governmental committees, but do not contain documented evidence of health impairments. In 1998 the BMA published the "conclusion that the decisions regarding the environment and health should be evidence-based and that where there is uncertainty 'the precautionary principle' should always be applied" (7). In 1998 The Royal Society highlighted the issue of progression of antibiotic resistance through the food chain, and called for further research as to whether gene transfer of antibiotic resistance could occur, and to what extent (8). Also, the BMA states: "further research and tests on GM foodstuffs for allergenicity needs to be undertaken"(6). It strongly advocates large, population based medical studies of humans living near GE food producers, acknowledging that human health effects due to GMOs "might only affect small numbers of people, symptoms could be unusual or idiosyncratic, difficult to ascribe to GMOs, or take many years before resulting in frank illness". Such surveillance programs have not been set up, due to complexity and cost. One recent, extensive local review of the subject of GE crops in SLO County includes opposing opinions about the potential or actual health dangers of GE crops (4).

Recently, the Institute of Medicine (IOM), one of the most prestigious national scientific academies, started a project in collaboration with: the Committee on Agricultural Biotechnology, Health and the Environment (CABHE), the Board on Agriculture and Natural Resources, the Food and Nutrition Board, and the Board on Life Sciences. "Over 18 months scientists from 15 universities will outline science-based approaches to assessing (or predicting) unintended health effects of genetically engineered foods" (11). It "will focus on: 1) molecular mechanisms by which unintended changes in the biochemical composition of food from common domesticated crops occur as a result of various conventional and genetic engineering plant breeding and propagation methods, and the extent to which these mechanisms are likely to lead to significant compositional changes in foods that would not be readily apparent without new or enhanced detection methods, and 2) methods to detect such changes in food, as warranted, and to determine their potential human health effects".

Marked concerns also exist about the uptake of "promoter" genes from bacteria or viruses in foods into humans. Although to date neither food nor human health differences have been shown, further study is necessary, perhaps using the techniques outlined above by the IOM, and the BMA.

Another major health concern about GE foods is the possibility of unknowingly creating or enhancing allergens via the introduction of new proteins or carbohydrates. Inadvertent creation of allergens or toxins is not limited to GMOs, but also occurs by classical breeding technologies (5), and likely also by same species transgenic manipulations. Indeed, introduction of unmodified "natural" Kiwi fruit to U.S. markets in the late 1960s was associated with unexpected cross-reactions with latex rubber (5). This suggests that natural selection, classical breeding techniques, and GE food creation may all have a risk of introducing potential new allergens. Conversely, GE could be used to reduce or eliminate specific allergens. For example, "knockout" of the P34 gene in soy leads to absent antibody responses in persons allergic to soy, who are then fed this product (13). P34 is responsible for 75% of soy allergies, but 15 other proteins also contribute. Other allergen "knockout" work focuses on wheat, peanuts, and milk (5). Microbial pesticides, in large scale use for 30 years, in an attempt to avoid the toxicities of many chemical pesticides, have not had extensive allergy testing. One controlled human study of B. thuringiensis showed increased humoral and skin test immunogenicity, but almost no evidence of clinical allergic change (14).

Concerns about horizontal gene transfer from foods to humans are also raised. However: a) digestion breaks down most proteins and DNA; b) rats fed large quantities of DNA exhibit no observable consequences; c) Humans have eaten foods, and thus their proteins and DNA, for millennia but few have taken on the characteristics of the foods we eat (5). Antibiotic resistance genes in foods are a concern, but the majority of gut bacteria resistance is due to indiscriminate antibiotic use in human health care and animal husbandry. We should not ignore the issue, but focus our resources carefully.

Summary: Much of the GE food debate centers on whose "science" one accepts, and on widely divergent views of credibility and trust, particularly regarding government agencies, industry, and sources of research funding. Many activists are concerned that despite claims of rigorous testing, unforeseen health problems may later arise. Their options include more stringent and very prolonged food and human testing, mandatory labeling, or a complete ban of all GMOs. "Superorganics" may solve some health-related concerns, but consumer anxiety about GE foods vs. higher crop yields, and plant production of vitamins, vaccines and pharmaceuticals is ultimately a risk-benefit ratio question. One potential solution is for FDA consultation to become mandatory, and for expert panel review and approval to be required.

Whenever any new product is introduced (food, fuel, chemical, material for manufacturing, etc), or 'contaminant identification' technology is improved, or safety thresholds are lowered, the ultimate consumer concern is **health risk**. Since better science always introduces new questions, the specter of risk and consumer concern will never completely disappear. Practically speaking, in the face of uncertainty, the use of precaution, and the application of science-based approaches to assessment of unintended health effects of GMOs in SLO County seem reasonable. This encourages dialogue, and permits ongoing local, national and international assessment of the impacts of new advances in food science.

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